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DEVELOPMENT OF TRIP GENERATION MODEL USING ACTIVITY BASED APPROACH

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ABSTRACT

Trip generation for work is one of the main purposes of travel in the urban areas. Activity based methods predicts behavior of traveler as derivative of activities. By predicting which activity performed at particular destination and time, trips and their timing and locations are used to develop activity based trip generation models. The aim of this paper is to develop activity based trip generation model which addresses shortcomings of the conventional trip based approach. In this study, trip generation model phenomenon has been studied for households in Trimurti Nagar in Nagpur city. Home-interview method is adopted to collect data to develop the trip generation model. Activity patterns are classified into five types and selected as dependent variables while other variables like age, gender, income, travel time, travel cost, etc., are selected as independent variables in the NLOGIT package to obtain the most statistically well accepted predicted activity pattern of individuals. The goal of the paper is to determine activity travel pattern behavior of individual and development of activity travel pattern choice model for work commuters and calculate the aggregated travel demand for Transportation Analysis Zone i.e. Trimurti Nagar, Nagpur

KEYWORDS: Activity Base Approach, Trip Rate, Travel Data, Work Commuters, Trip Based Approach, Activity Patterns, Choice Model

INTRODUCTION

Transportation forecasting is a science which used to study the problem that arises in providing transportation planning in urban, regional or national setting and to prepare a systematic basis for planning. System approaches with the decision to adopt planning, problem, definition, formulation of goals. Transportation forecasting generating and analyzing the solution then evaluate possible alternatives and choices then implemented and operate.

Activity Based Approach

The activity based approach is the practical tool which overcomes problems in traditional methods such trip based approach. Activity based travel demand analysis views travel as a derived demand; derived from the need to pursue activities distributed in space. The approach adopts a holistic framework that recognized the complex interaction between activity and travel behavior. The conceptual appeal of this approach originates from the realization that the need and desire to participate in activities is more basic than the travel that some of these participation may entail. By placing primary emphasis on activity participation and focusing in sequence or patterns of activity behavior such an approach can address congestion–management issues through an examination of how people modify their activity participation. The origin of the

activity-based approach dates back to the 1960s from based approaches to travel demand forecasting or quantitative policy analysis are practically non existence.

Activity based approach provide theoretically and conceptually stronger framework within which the travel demand modeling may be performed in Figure 1.

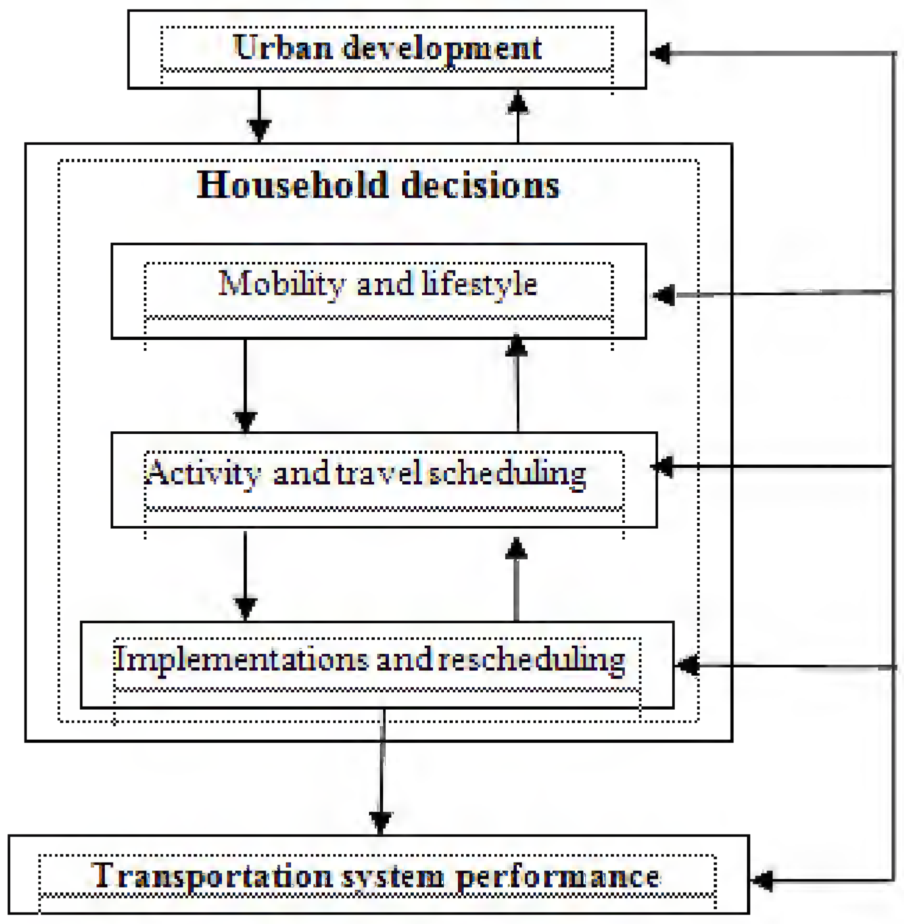


Figure 1: Activities and Travel Demand Framework

The following elements can be considered as the core of the activity based approach [4]:

- Travel is derived from the need to change the location between two successive activities.
- Movements undertaken for their own sake are an exception. For example: walking the dog, cycling through the countryside.
- Individual schedule their own activities in co-ordination with the members of household or of their social network.
- Individual are the constraints in their scheduling because of the resources available to them in particular vehicle.
- Individual are the constraints because of their longer term commitments to their household members, to their resident location and to their work place.

Trip Generation

The first phase of transportation forecasting process deals various survey, data collection and inventory. The next phase is to analyze the collecting data and building the various models which describe trip behavior of individual. The analysis and model building phase starts with the step commonly known as Trip generation. The trip generation aims at predicting the total number of trips generated and attracted to each zone of the study area. In other words, this stage answers the simple questions to "how many trips" originate at each zone. Trip generation is a term used in the transportation forecasting to cover the area of calculating the number of trips. The following elements are taken into consideration for activity based trip generation:

Types of Trip

Journey is an out way movement from a point of origin to a point of destination, where as the word "trip" denotes an outward and return journey. If either origin or destination of a trip is the home of the trip maker then such trips are

called home based trips and the rest of the trips which origin or destination is not home are called non home based trips.

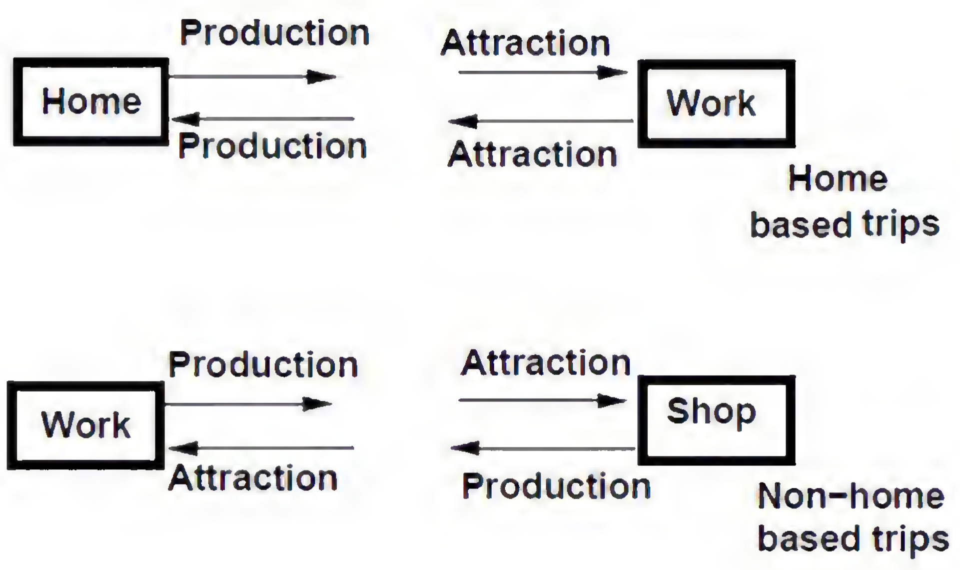


Figure 2: Types of Trips

Purpose of Trip

The activity travel pattern is defined as an individual level depiction of the activity type, distance from home, distance from last activity, mode used, or other variables of interest over a 24 hour time period. All out of home activity types are defined in the manner: work such as work related and school activities, maintenance such as dine out and shopping type activities, recreationary such visiting friends and social party type activities. Next all in home activities are characterized as home.

Factors Affecting Trip Generation

The main factors affecting personal trip production includes income, vehicle ownership, house hold structure and family size. In addition factors like value of land, residential density and accessibility are also considered for modeling at zonal levels. The personal trip attraction, on the other hand, is influenced by factors such as roofed space available for industrial, commercial and other services. At the zonal level zonal employment and accessibility are also used. In trip generation modeling in addition to personal trips, freight trips are also of interest. Although the latter comprises about 20 percent of trips, their contribution to the congestion is significant.

LITERATURE REVIEW

Jones et. al. (1990) developed a comprehensive definition of activity analysis as: it is a "framework in which travel is analyzed as daily or multi-day patterns of behavior, related to and derived from differences in life styles and activity participation among the population." The "emerging features" of activity analysis are identified (Jones et. al., 1990) as:

- Treatment of travel as a demand derived from the desires, demand to participate in other, non-travel activities.
- Focus on sequences or patterns of behavior, not discrete trips.
- Analysis of households as the decision-making units.
- Examination of detailed timing and duration of activities and travel.
- Use of household and person classification schemes based on differences in activity needs, commitments and constraints.

Kitamura (1988) provided this inattention by the practitioners' community to the fact that the activity-based approach is not suited for the evaluation of capital-intensive, large-scale projects, but it is better suited for refined, often

small-scale transportation policy measures. Unfortunately small-scale projects can rarely afford elaborate analysis. This is no longer the case, at least in the United States where the importance of refined transportation control measures is well recognized and efforts are being made to promote their implementation and to assess their potential effectiveness travel activities.

Sheppard (1986) studied cross-classification (category) models have been more widely used for long range residential trip generation analysis to overcome some of the inherent problems with regression analysis. Cross-classification models were explored in the late 1960s. Similar to regression-based approaches, cross-classification models relate characteristics of households to demand for travel. Cross-classification models differ in the number and type of individual and household characteristics that are related to travel demand. Regression models tend to be good describers but not good predictors because assumptions about travel behaviour may not hold and because of problems with multi-co-linearity of variables. Further, category analysis works best for independent variables that can only take on discrete values. From the above mentioned points, there is a strong need to develop a travel demand forecasting process for Gaza City to understand travel characteristic pattern and to determine the performance of its transportation infrastructure. In this study, we begin with developing a model for the first step in this process which is trip generation.

Wootton & Pick (1967) studied disadvantage of the trip based method. It is being empirical in nature. It cannot provide a real insight into the mechanism of trip generation or establish casual relationships between the dependent and independent variables. To use the method for projection involves the assumption that regression coefficients established at a given time are relevant at some future time. This assumption, is being unsatisfactory because it is not clear what, in terms of physical experience, is being assumed, i.e. The meaning of a regression coefficient is not easily interpreted.

RESEARCH METHODOLOGY

To achieve the research objectives, the general requirements of flowchart to cover of data collection were planned as illustrated in Figure 3

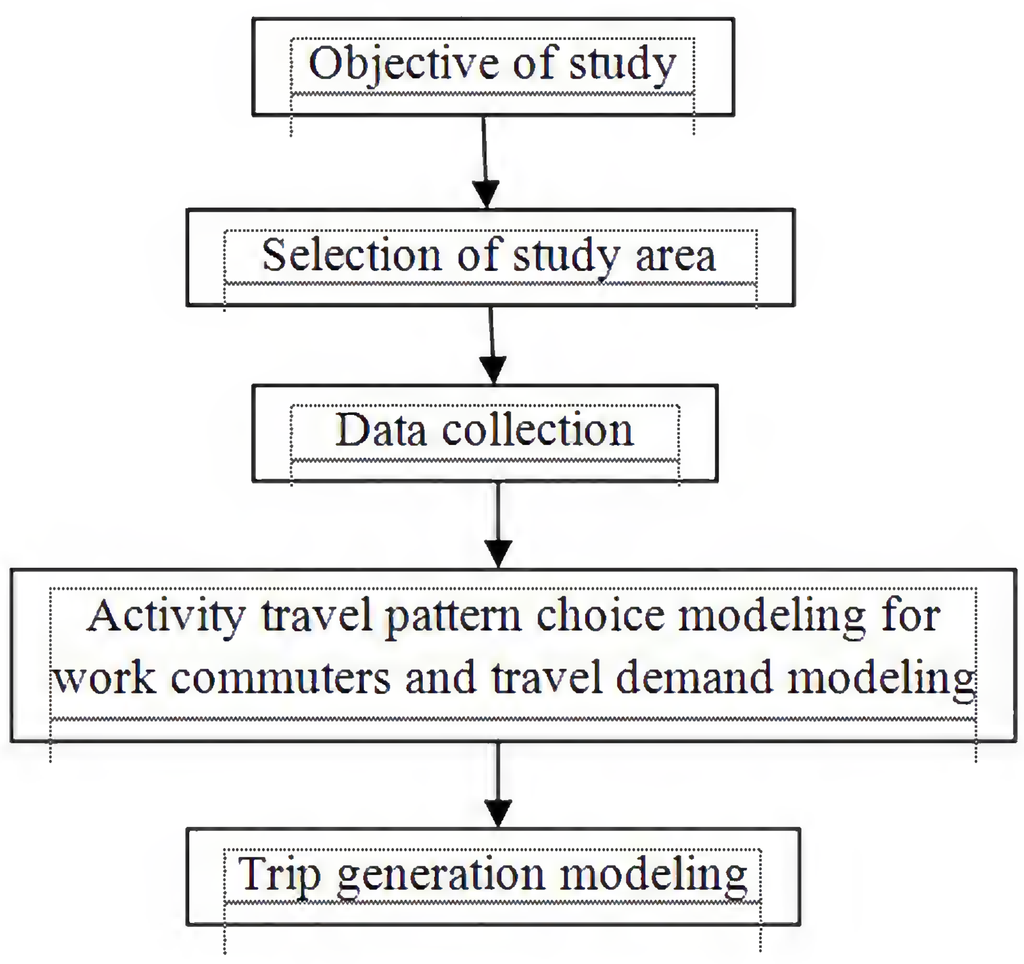


Figure 3: Flowchart of Various Stages Involved in Research Study

Selection and Description of the Study Area

For the transportation planning of Nagpur city, it is divided into the numbers of zones. These zones are known as the transportation analysis zones (TAZ) which is used to determine trip generation rate. In this study Trimurti nagar as shown in Figure 5 is taken as the Transportation Analysis Zone (TAZ). It consist small colonies such as Sambhaji nagar,

Shubhash nagar, Sainath nagar and Loksewa nagar. The population of Trimurti nagar is about 9186 and consists about 1802 households. As the population of the study area is under 50,000, the data were collected with the minimum sample size is 1 in 10 household as per[Bureau of Public Road, Procedure Manual: Conducting A Home Interview Origin-Destination Survey, Vol. 2B. Washington, 1956] According to it the household survey or home interviews survey was carried out of 180 households.

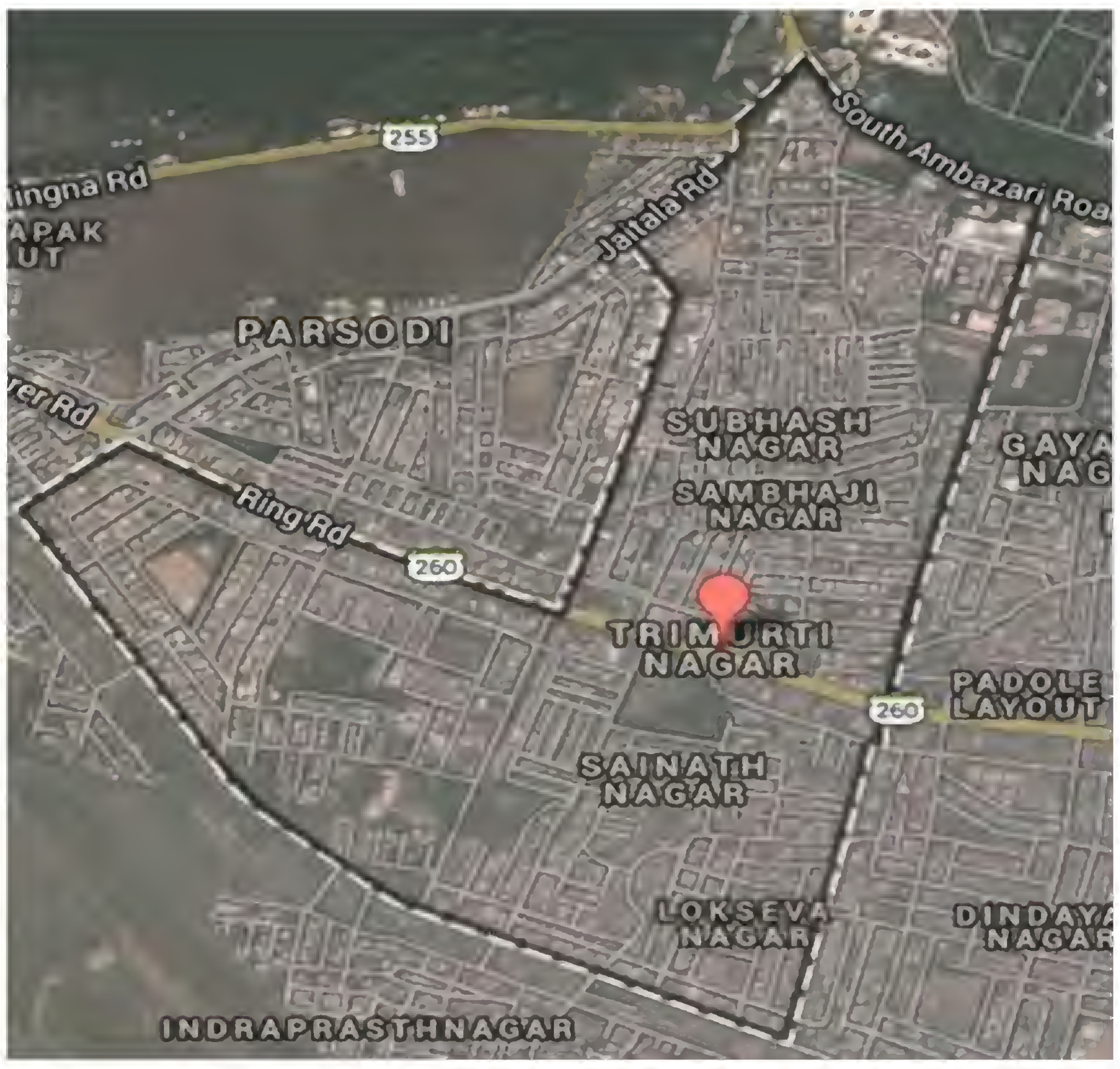


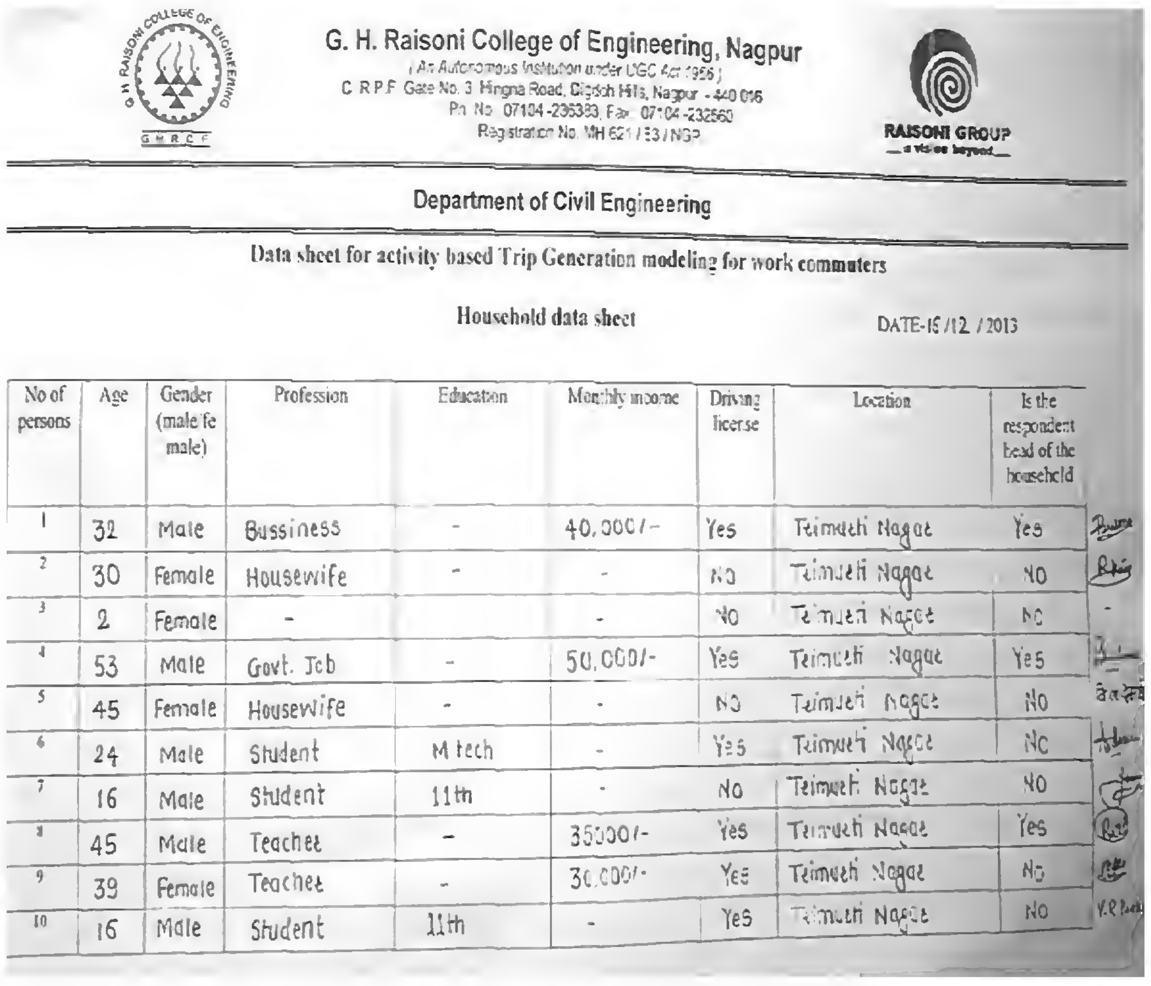
Figure 4: Map of Trimurti Nagar, Nagpur City

Data Collection

The home interview surveys are the most common accepted source of collecting information for planning. Prior to any survey or data collection, the purpose and area of the study must be clear defined. Data collection is an expensive and time consuming process.

Using Home interview survey data was collected for 180 families. Data sheet consist activity data sheet and household data sheet about the zone additional characteristics are shown in figure 5 and 6. According to collected data, all trips are classified in 5 types as follows:

(hwh)	Home to work and work to home
(hw+h)	Home to work and work to home with additional stop
(hwhwh)	Tour with sub-tour and back to home
(hwh++h)	One primary tour with at least one secondary tour
(hw+wh)	Tour with sub-tour and back to home with non-work activity



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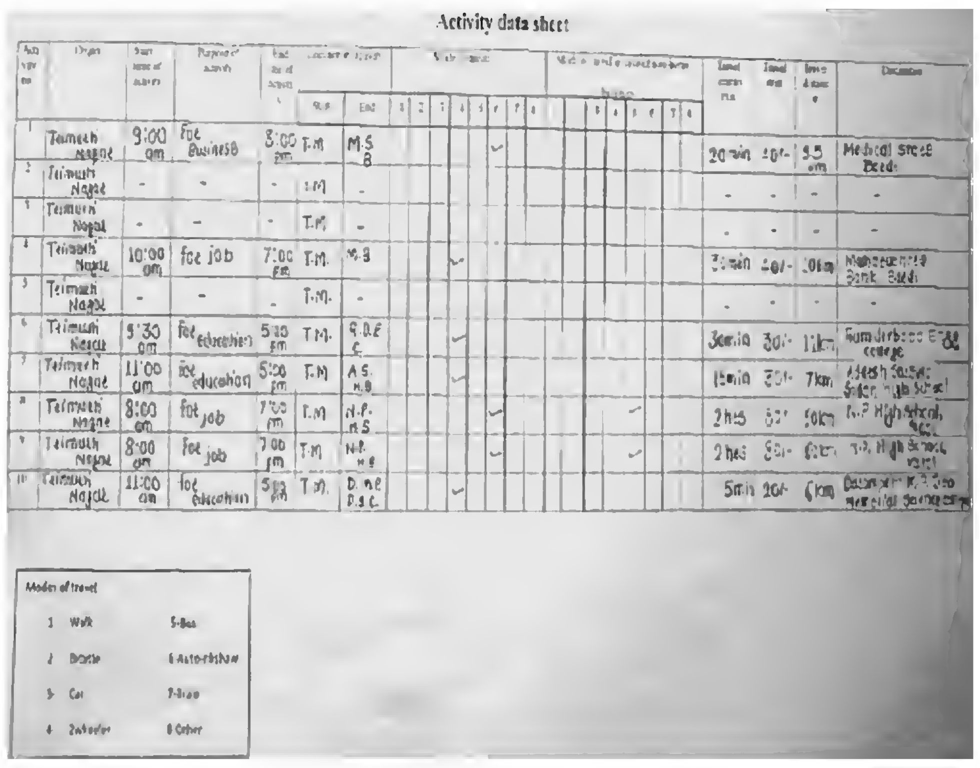
Data sheet for activity based Trip Generation modeling for work commuters

Household data sheet

DATE-15/12/2013

No of persons	Age	Gender (male/female)	Profession	Education	Monthly income	Driving license	Location	Is the respondent head of the household
1	32	Male	Bussiness	-	40,000/-	Yes	Trimurti Nagar	Yes
2	30	Female	Housewife	-	-	No	Trimurti Nagar	No
3	2	Female	-		-	No	Trimurti Nagar	No
4	53	Male	Govt. Job	-	50,000/-	Yes	Trimurti Nagar	Yes
5	45	Female	Housewife	-	-	No	Trimurti Nagar	No
6	24	Male	Student	M tech	-	Yes	Trimurti Nagar	No
7	16	Male	Student	11th	-	No	Trimurti Nagar	No
8	45	Male	Teacher	-	35000/-	Yes	Trimurti Nagar	Yes
9	39	Female	Teacher	-	30,000/-	Yes	Trimurti Nagar	No
10	16	Male	Student	11th	-	Yes	Trimurti Nagar	No

Figure 5: Household Data Sheet



Activity data sheet

Modes of travel
1 Walk 5 Bus
2 Bicycle 6 Auto-rickshaw
3 Car 7 Train
4 2wheeler 8 Other

Figure 6: Activity Data Sheet

According to the collected data, the length and frequency distribution for five typical patterns is done as shown in Table 1. The length of activity pattern is equal to total numbers of trips included in pattern. From Table 1, it is clear about 45% of work commuters make a simple tour i.e. hwh and activity pattern hw+h and hwhwh take second and third place respectively. The fourth place is taken by hwh++h activity pattern. The percentage of hw+wh pattern is 5.38% it means the commuter make this tour very rarely. From results, it is clear that during morning and evening commute non work activity are very less.

Table 1: Distribution of Activity Pattern Based on Length and Frequency of Trips

Activity Pattern	Description	Length (No of Trips)	Frequency (%)
hwh	Home to work and work to home	2	45.38%
hw+h	Home to work and work to home with additional stop.	3	18.46%
hwhwh	Tour with sub-tour and back to home.	4	17.69%
hw+wh	Tour with sub-tour and back to home with non-work activity	4	5.38%
hwh++h	One primary tour with at least one secondary tour	5	13.09%

EFFECT OF VARIABLES

Effect of Age on the Activity Travel Pattern

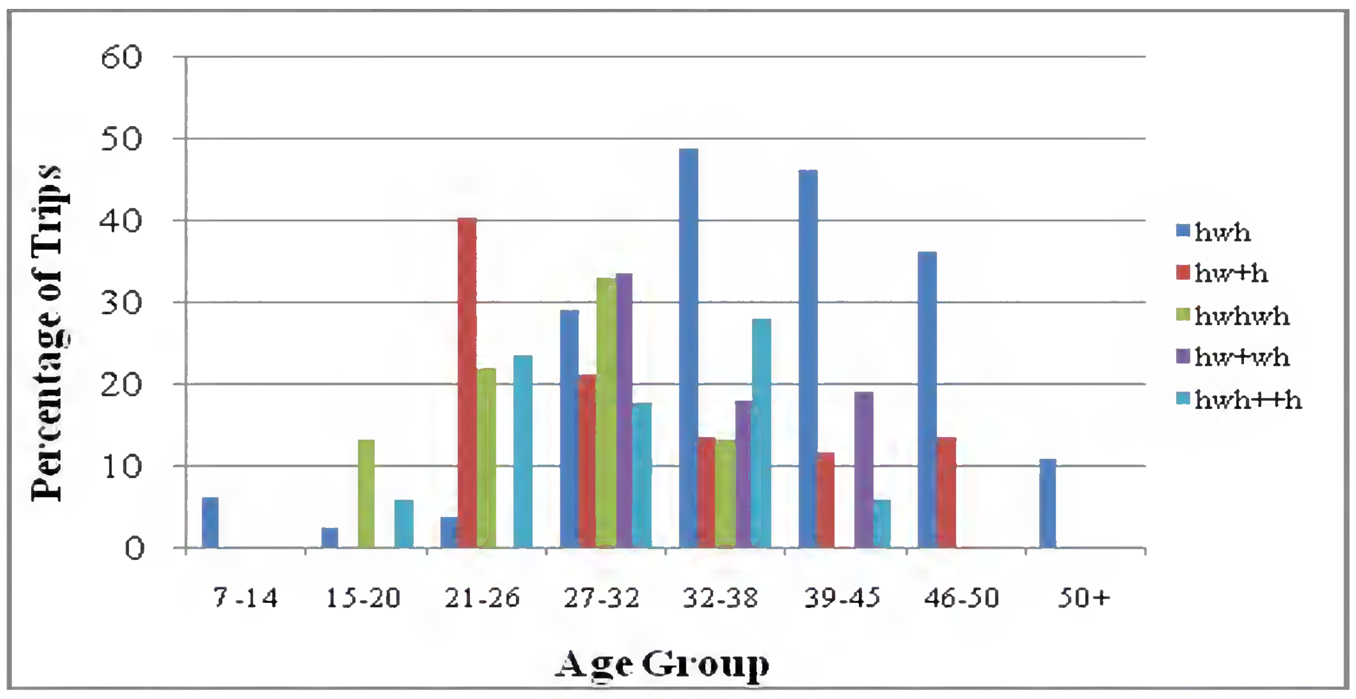


Figure 7: Effect of Age on the Activity Travel Pattern

Figure 7 shows percentage of trips by different age a group. It is clear that the people in the age range 38 to 50 mostly involved in the simple tour home to work and back again home with no additional stop. As the age of the respondent increases the selection of complex tour decreases. The percentage of selection of tour with at least one stop for non work activity (hw+h) and the tour with sub tour returning home (hwhwh) is more common in the age range of 15 to 32. The percentage of section of tour with work based sub tour (hw+wh) pattern is more in the age range of 27 to 38, similarly the percentage of selection of complex activity pattern with both primary tour and at least one secondary tour (hwh++h) is more common in the age range of 21 to 38. The graph of this observed value is presented in Figure 7.

Effect of Mode on the Activity Travel Pattern

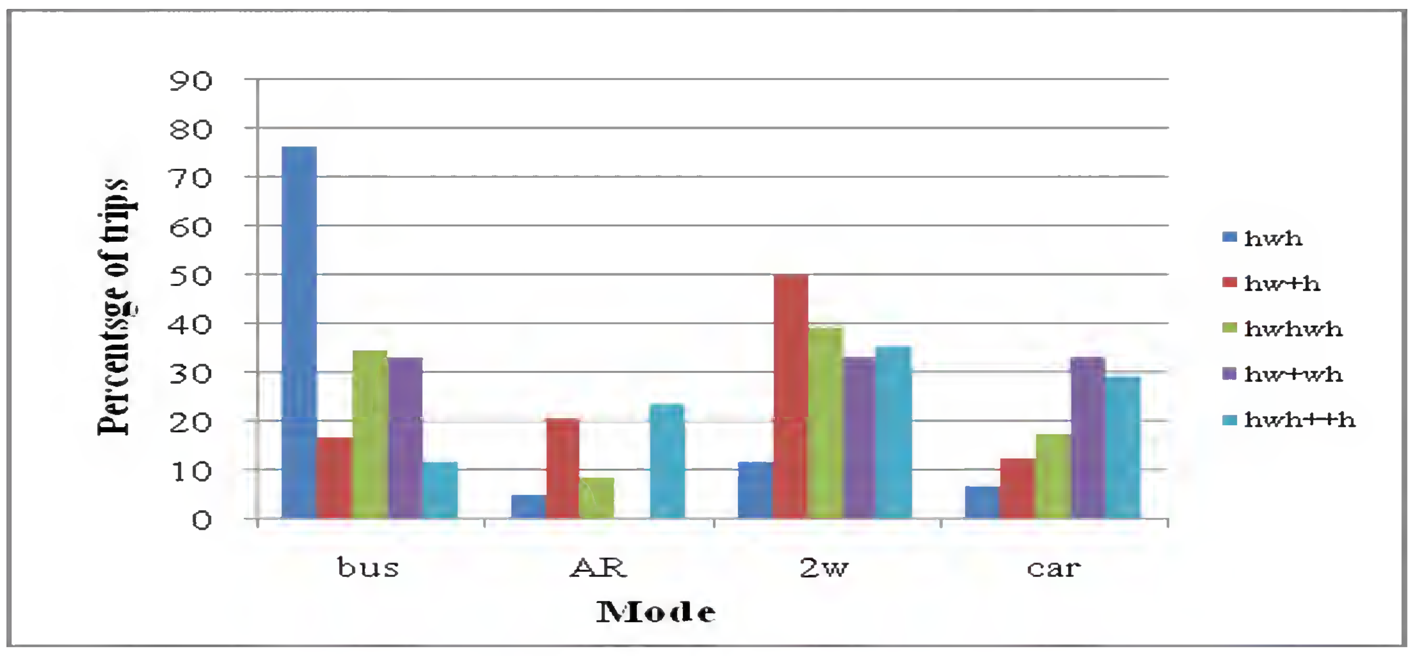


Figure 8: Effect of Mode on the Activity Travel Pattern

Figure 8 shows the impact of mode used for travel on the activity travel pattern. From figure it is clear that most of the commuters use the bus as a mode of travel for simple activity pattern (hwh). Second place is taken by 2 Wheeler. For the complex tour most of the commuter choose private vehicle i.e. two-wheeler, Car etc. The percentage of complex tour by bus is very less. Tours by auto rickshaw are very less. For the tour with sub tour for work (hw+wh) the people mostly use the car as mode of travel. For the activity pattern with at least one additional stop for non work activity (hw+h) people use two–wheeler as mode of travel. In case of private transport the percentage of selection of two –wheeler as mode of travel is more than the car.

Effect of Profession on the Activity Travel Pattern

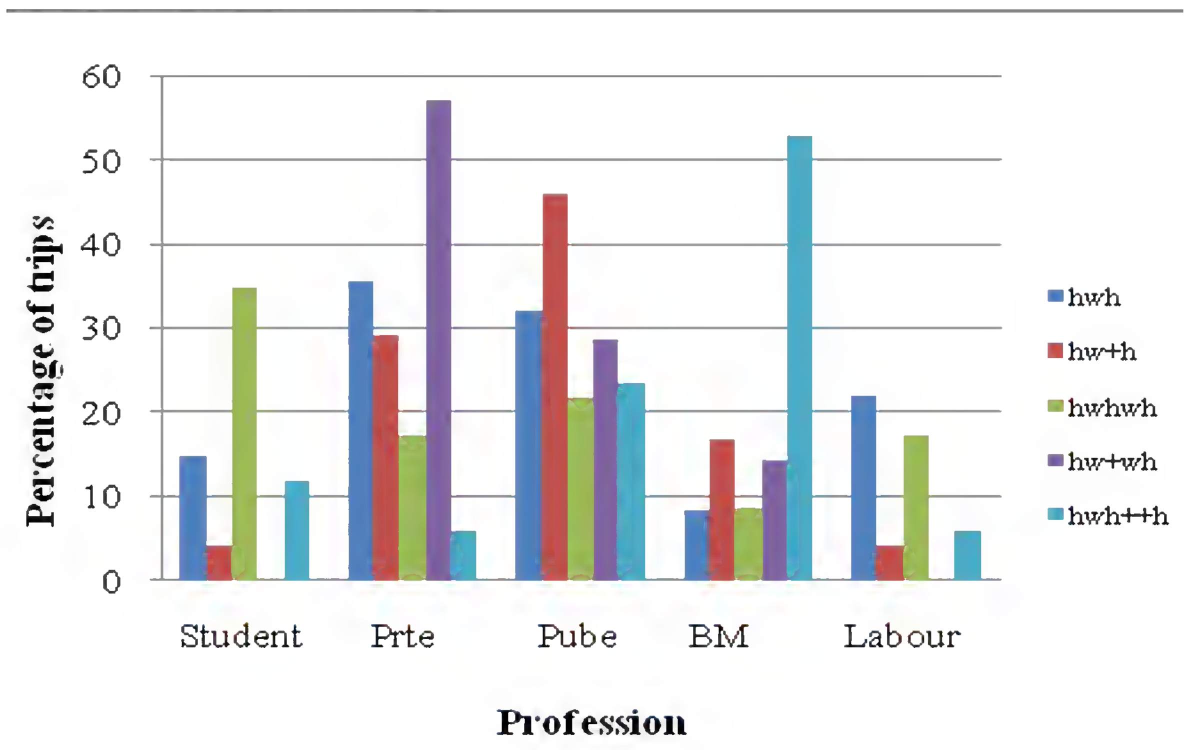


Figure 9: Effect of Profession on the Activity Travel Pattern

Where,

Pube- Public sector employee

Prte- Private sector employee

BM- Businessmen

From Figure 9 it is clear that the percentage of simple tour is highest in private sector employee where as the public sector employee takes the second place. The percentage of tour with sub tour returning to home (hwhwh) is highest among students and the second choice of student is simple tour from home to work and back again to home without any additional stop. The percentage of complex tour with both simple tour and at least on secondary tour (hwh++h) is highest among the business man. Public sector employee makes the tour with at least one stop for non work activity (hw+h). First choice of labour is simple tour (hwh) and their second choice of activity pattern is the tour with sub tour returning to home (hwhwh). The percentage of tour with sub tour for work (hw+wh) is very less among the student and lobour. The percentage of tour with sub tour for work (hw+wh) is high among the private sector employee

Effect of Gender on the Activity Travel Pattern

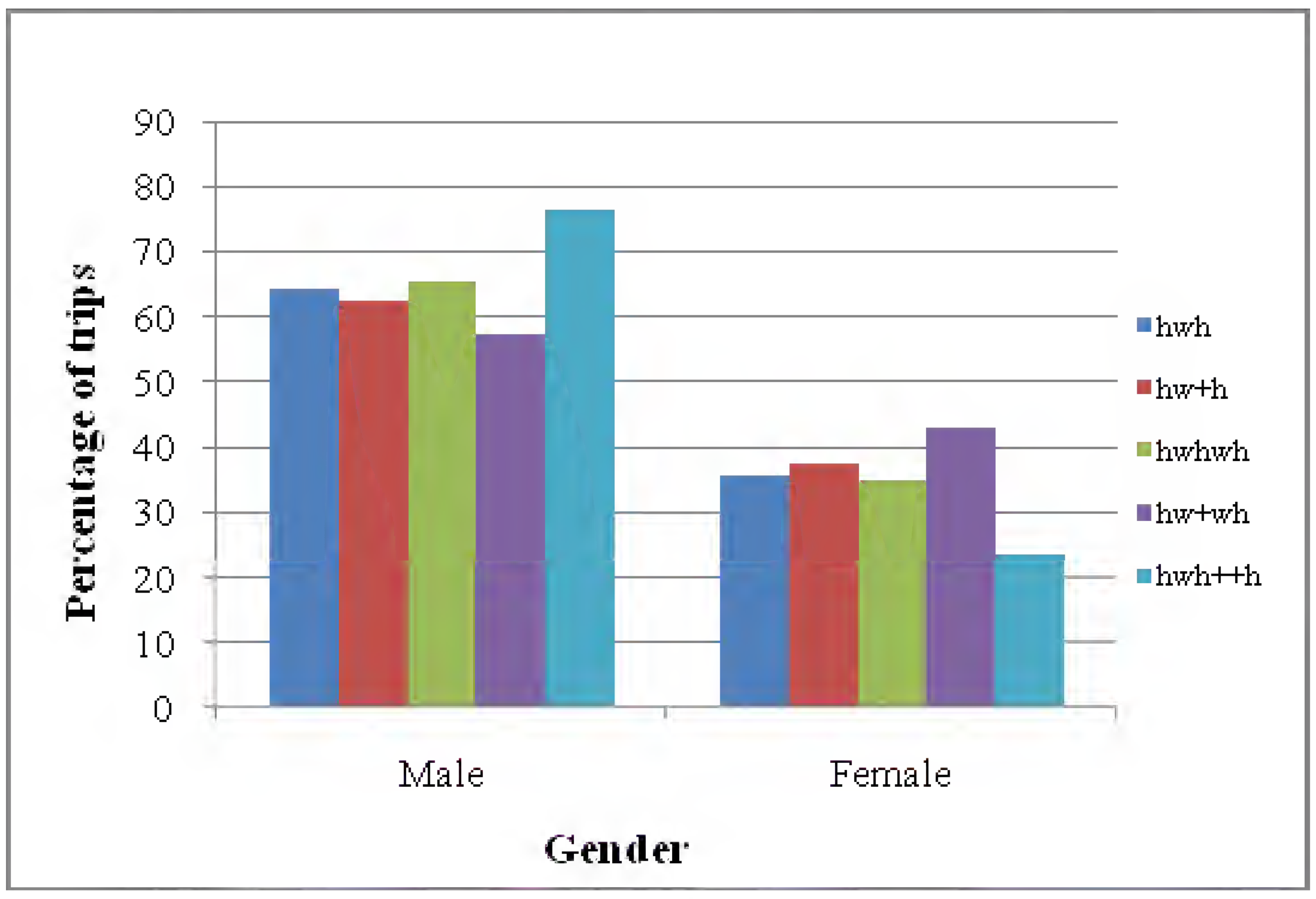


Figure 10: Effect of Gender on the Activity Travel Pattern

From figure 10 it is clear that number of work trips made by male is higher than female for all five types of activity pattern. Among the five activity travel pattern simple activity tour (hwh) is highly selected by females and second choice of tour by female is Tour with at least one additional stop for non work activity (hw+h).

Effect of Travel Distance on the Activity Travel Pattern

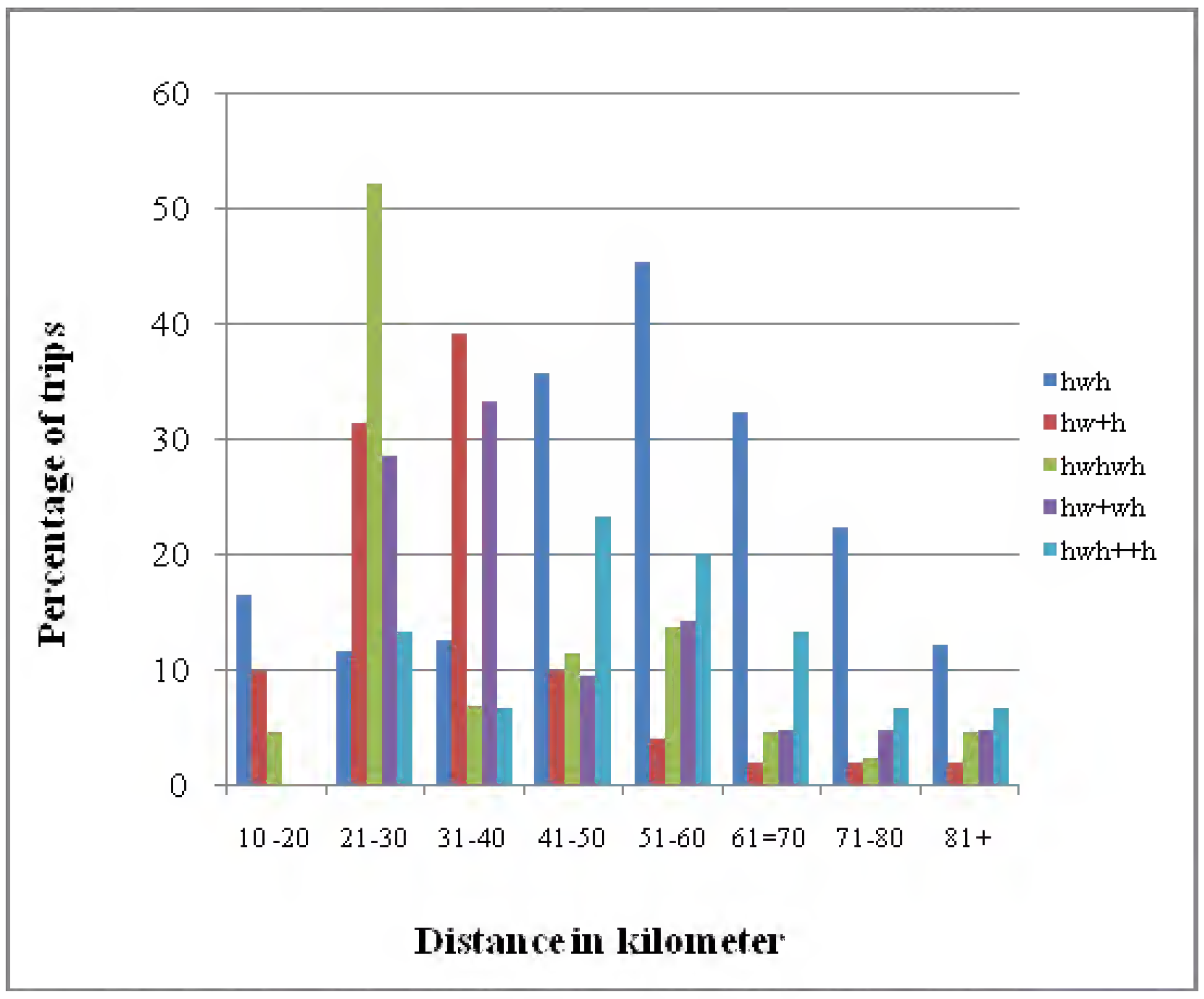


Figure 11: Effect of Travel Distance on the Activity Travel Pattern

Figure 11 shows the effect of travel distance on activity travel pattern. The curve of simple tour from home to work and back again back to home without any additional stop (hwh) is sharp for the distance range 51 to 60 km, it means for longer travel distance commuter choose the simple tour. The percentage of tour with sub tour returning to home (hwhwh) is highest in distance range of 20 to 30 km and the percentage of selection of tour with at least one additional stop for non work activity (hw+h) and the tour with work based sub tour (hw+wh) is high in the distance range of 31 to 40 km. similarly From above discussion it is clear that as the travel distance increases the most of the commuter makes the simple tour (hwh). The percentage of selection of the complex tour with both primary tour and at least one secondary tour (hwh++h) is high in the distance range of 41 to 50 km

Effect of Travel Time on the Activity Travel Pattern

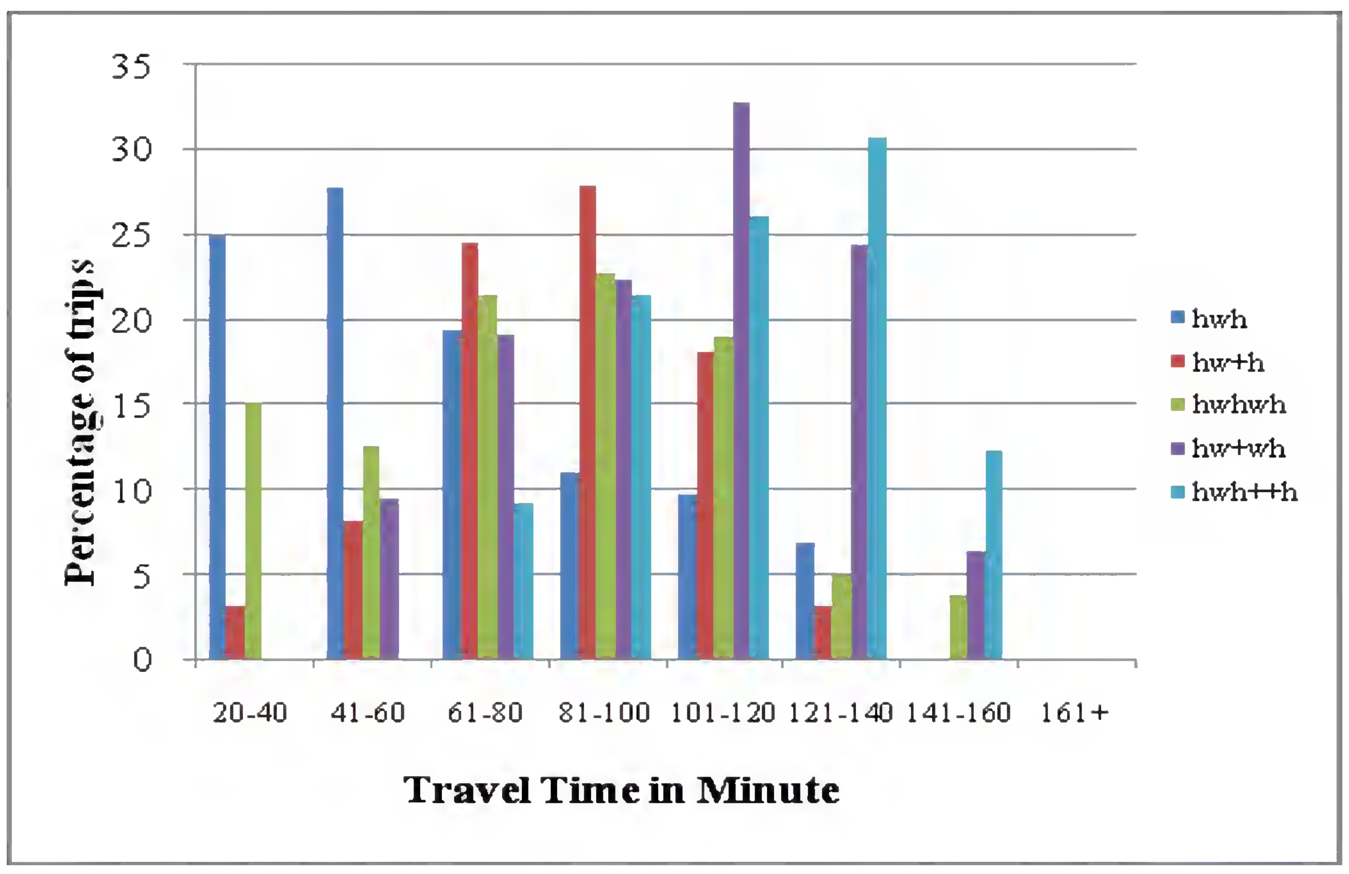


Figure 12: Effect of Travel Time on the Activity Travel Pattern

Figure 12 shows the effect of travel time on activity travel pattern. For the travel time range 20 to 40 minute 25 percent of people choose the simple tour from home to work and back again to home without any additional stop for non work activity (hwh). The second place is taken by tour with sub tour returning to home. The percentage of selection of the simple tour from home to work and back again to home without any additional stop for non work activity (hwh) is high in the range of 41 to 60 minute. The percentage of selection of the tour with at least one stop for non work activity (hw+h) is high in the range of 81 to 100 minute. For the range of 121 to 140 minute the percentage of complex tour with both primary tour and at least one secondary tour (hwh++h) is highest among all type of the activity travel pattern. For the range of 101 to 120 minute the percentage of the tour with work based sub tour (hw+wh) is high

Effect of Travel Cost on the Activity Travel Pattern

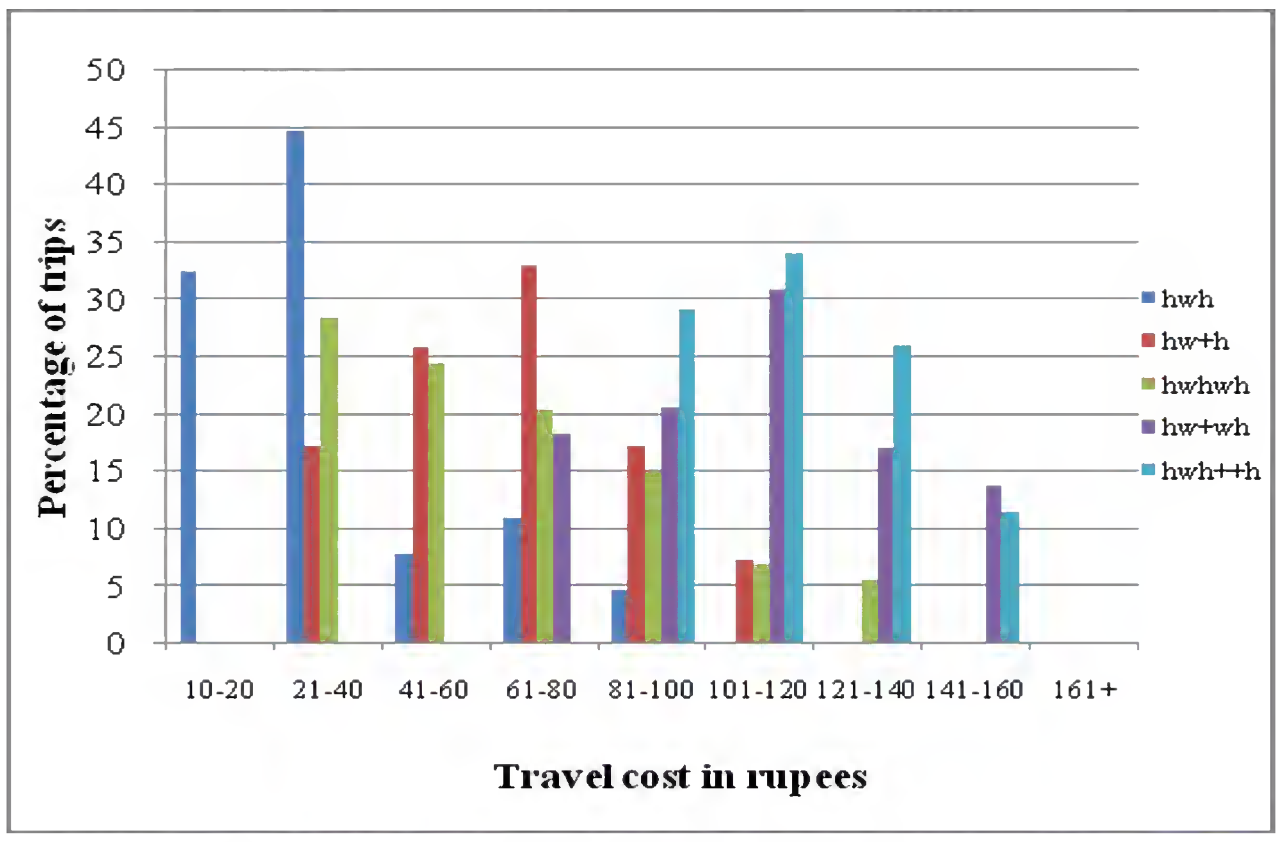


Figure 13: Effect of Travel Cost on the Activity Travel Pattern

Figure 13 represents the effect of travel cost on the activity travel pattern. Form the range of 10 to 20 rupees, the percentage of simple tour form home to work and back again to home without any additional stop for non work activity (hwh) is more than other complex activity travel pattern. The percentage of selection of simple activity pattern is high in the range of 21 to 40 rupees. The percentage of selection of the tour with at least on e stop for non work activity (hw+h) is high in the range of 60 to 80 rupees. For the range of 101 to 120 rupees, the percentage of selection of complex tour with both primary tour and at least one secondary tour (hwh++h) is highest among all type of activity travel pattern. For the range of 141 to 160 rupees, the percentage of selection of the tour with work based sub tour is more than other activity travel pattern

Effect of Monthly Income of Respondent on the Activity Travel Pattern

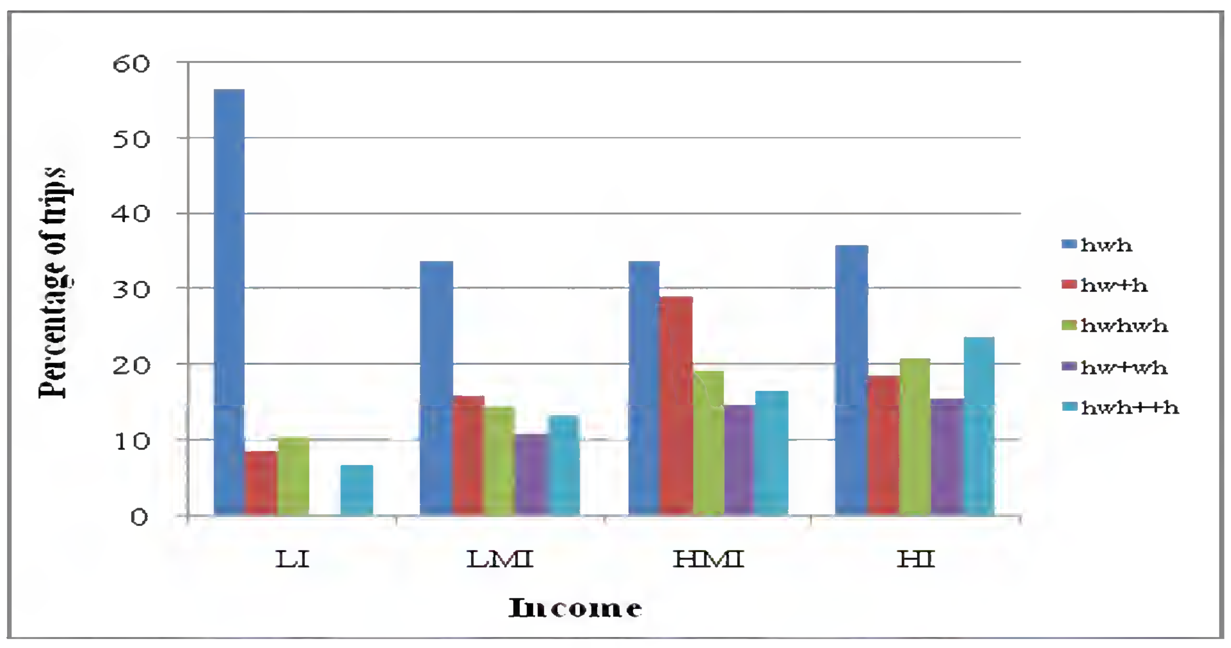


Figure 14: Effect of Monthly Income of Respondent on the Activity Travel Pattern

Figure 14 of effect of monthly income of respondent on the activity travel pattern shows the percentage of trips made according to monthly income the respondent. As mentioned earlier the income of the respondent is classified into four categories LI, LMI, HMI, and HI. From figure it is clear that all type of income group people is mostly involved in simple activity pattern home to work and again back to the home without any stop (hwh), but the percentage of simple activity pattern is more among the low income group people. The percentages of the tour with at least one additional stop for non work activity (hw+h) is more in higher middle income group people similarly the percentage of complex tour with both primary and at least one secondary tour (hwh++h) is more in the higher income group people.

MODEL FOR ACTIVITY TRAVEL PATTERN CHOICE

Define Variables and its Coefficient

Y= Dependent variable=**U** (activity pattern),

X= Independent variables (x_1, x_2,….,x_n)

a= Coefficients of variables ($a_{1,}$ $a_{2,\ldots}a_n$)

n= 15

U= Utility function of activity pattern

Variables and Coefficient Used in Mathematical Model are as Follows

Y= Travel Demand

Y1= Travel Demand for hwh

Y2= Travel Demand for hw+h

Y3= Travel Demand for hwhwh

Y4= Travel Demand for hwh++h

Y5= Travel Demand for hw+whh

X1= Head of Household= hoh

X2= Gender

X3= Student

X4= Private Sector Employees=prte

X5= Public Sector Employees=pube

X6= Businessmen=bm

X7= Labour

X8= Age

X9= Income

X10= Vehicle Ownership=vw

X11= Public Transport=pubt

X12= Private Transport=prt

X13= Travel Time in Minute=ttmin

X14= Travel Cost=tc

X15= Travel Distance in Kilometer=tdkm

a1= Coefficient of Hoh

a2= Coefficient of Gender

a3= Coefficient of Gender

a4= Coefficient of prte

a5= Coefficient of pube

a6= Coefficient of bm

a7= Coefficient of Labour

a8= Coefficient of Age

a9= Coefficient of Income

a10= coefficient of vw

a11= Coefficient of pubt

a12= Coefficient of prt

a13= Coefficient of ttmin

a14= Coefficient of tc

a15= Coefficient of tdkm

a16, a17, a18, a19 are constant coefficients.

To develop the models for travel pattern choice for work commuter, the standard NLOGIT package has been adopted. It is extension of LIMited DEPendent Variable Models (LIMDEP).It also known as Nested LOGIT Models (NLOGIT).

The Tables Present the Results of Activity Pattern Choice Analysis for all Activity Travel Patterns

Tables are given below:

Table 2: Shows Variables, T-Ratio and Coefficient for Activity Pattern hwh

Variables	Coefficient	T Ratio
hoh	0.9681122	1.187
gender	-0.1145821	-0.585
student	0.08252881	1.093
pre	1.15532467	4.877

Table 2: Contd.,

pube	0.38559604	2.184
Bm	0.01966141	0.198
labour	0.09250653	2.017
educ	-0.8850725	-0.932
age	-0.3506404	-2.371
income	-0.197205	-2.075
nfm	-0.0745126	-0.918
vw	0.06303866	0.604
pubt	0.26940378	6.47
prt	0.09484292	1.104
ttmin	-0.0277223	-0.976
tc	-0.0525138	-2.817
tdkm	-0.0532336	-0.755

Table 3: Shows Variables, T-Ratio and Coefficient for Activity Pattern Hw+H

Variables	Coefficient	T Ratio
hoh	1.2523881	2.266
gender	-2.3426096	-1.717
student	0.02057009	0.208
pre	0.3259851	2.141
pube	0.39256214	5.094
bm	0.04096956	0.438
labour	0.02150109	0.217
educ	-0.1196135	-0.342
age	-0.6890325	-1.014
income	0.190643	0.446
nfm	-0.0409698	-1.429
vw	0.97661121	2.036
pubt	1.15126269	2.379
prt	0.4202778	5.435
ttmin	-0.0278288	-2.081
tc	-0.3719106	-2.879
tdkm	-0.2440709	-0.878

Table 4: Shows Variables, T-Ratio and Coefficient for Activity Pattern Hwhwh

Variables	Coefficient	T Ratio
hoh	0.92484495	1.379
gender	-2.4438022	-1.848
student	1.05038514	6.308
pre	0.09300017	1.083
pube	0.08183882	1.08
bm	0.02150109	0.217
labour	0.02315993	2.233
educ	-0.0631871	-0.192
age	-0.1417719	-1.979
income	0.500011	1.14
nfm	-0.0251414	-0.878
vw	0.9795993	2.592
pubt	0.5852689	2.459
prt	2.21733199	4.335
ttmin	-0.1601899	-1.308
tc	-0.3301922	-2.485
tdkm	-0.3785812	-1.427

Table 5: Shows Variables, T-Ratio and Coefficient for Activity Pattern Hwh++H

Variables	Coefficient	T Ratio
hoh	1.2433451	2.313
gender	-2.8495795	-2.146
student	0.14618264	1.298
pre	0.07905742	0.405
pube	0.08134599	1.077
bm	0.14212966	3.285
labour	0.9281381	0.303
educ	-0.0318714	-0.107
age	-0.5245465	-0.734
income	0.377146	0.841
nfm	-0.0341661	-1.179
vw	0.39874664	2.808
pubt	0.3487675	0.761
prt	2.50857566	4.77
ttmin	-0.0148864	-1.178
tc	-0.3727139	-2.888
tdkm	-0.2953663	-1.068

Table 6: Shows Variables, T-Ratio and Coefficient for Activity Pattern Hw+Wh

Variables	Coefficient	T Ratio
hoh	1.35706231	1.649
gender	-2.1442393	-2.58
student	0.10557787	0.357
pre	0.14218664	1.297
pube	-0.2362337	-0.22
bm	0.12999406	0.444
labour	-0.3087444	-0.105
educ	-0.1628396	-0.473
age	-0.3584537	-0.514
income	0.04162396	1.417
nfm	-0.2673237	-0.55
vw	0.123139	0.282
pubt	0.09092551	1.059
prt	0.03739286	3.286
ttmin	-0.2937172	-2.202
tc	-0.4164309	-3.215
tdkm	-0.143202	-0.534

Table 7: Shows Alternate Specific Constant of Each Activity Pattern

Activity Pattern	Coefficient (Constant)	T Ratio (Constant)
A_HW+H	1.096	1.716
A_HWHWH	1.677	1.866
A_HW+WH	1.431	3.089
A_HWH++H	1.208	1.643

T-ratio is the ratio of coefficient to standard error

T-Ratio= (Coefficient/Standard Error)

According table 7 values of constant coefficients and t-ratios are given. The minimum value of constant T-ratio is 1.6. Therefore, variable is found to be significant if the T-ratio is greater than or equal to 1.6 and insignificant if less than 1.6, so it can say that T-ratio is the deciding factor to select the respective coefficient in the mathematical model.

Tables presents the variable PrE, PubE, Labour, PubT, age and TC are found to be more significant and the variable gender, Ttmin, nfm, Vw and Tdkm are found to be insignificant for the simple activity travel pattern with no additional stop (hwh). In case of tour with at least one additional stop for non work activity (hw+h) based on t-ratio the variable hoh, PubE, PrE, Vw and PrT are found to be more significant. The variable Tc, Ttmin, Tdkm shows the logical sign and found to be significant. For tour with sub tour returning home (hwhwh) the variables student, labor, PubT, Tc and PrT are found to be more significant. The variable Vw is found to be significant. The variable Educ and Nfm are found to be insignificant. Ttmin and Tc show the logical signs and found to be insignificant. For complex chain with both simple primary tour and at least one secondary tour (hwh++h) the variable hoh, BM Vw and PrT are found to be more significant. The variable Educ, age, and income are found to be insignificant. Ttmin and Tc show the logical signs and found to be significant. The variable PrE labour, and PubT are found to be insignificant for this activity pattern. In case of Tour with a work based sub tour for non work activity (hw+wh), Based on t-ratio the variable gender, PrT income and Tc are found to be more significant. The variable age, student, labour, BM, Pube, Educ, nfm, vw, Pubt and Tdkm are found to be insignificant. Among the five profession variables, the variable PrE is found to be more significant for the tour with work based subtour for non work activity (hw++wh). Also from NLOGIT packager get value of R^2 = 0.826

Activity Travel Pattern Choice Model i.e. Mathematical Model for Each Activity Pattern

Choice set is hwh, hw+h, hwhwh, hwh++h, hw+wh. For each activity pattern variables are hoh, gender, educ, prof, age, income, nfm, vw, mode, tc, tdkm, ttmin. As the choice behaviour of commuter differs from individual to individual. Each individual can choose any activity pattern. Logit models have been calibrated for choice set.

General Equation

$$Y=b+a_1*\mathbf{X_1}+a_2*\mathbf{X_2}+\ldots\ldots\ldots+a_n*\mathbf{X_n}$$

where, b= alternate constant

For Simple Tour from Home to Work and Work to Home with no Additional Stop

$$\mathbf{Y_1= U(hwh)}=1.15532467*\mathbf{X_4}+0.38559604*\mathbf{X_5}+0.09250653*\mathbf{X_7}-0.3506404*\mathbf{X_8}-0.197205*\mathbf{X_9}-0.0525138*\mathbf{X_{14}}$$

For Home to Work and Work to Home with Additional Stop

$$\mathbf{Y_2= U(hw+h)}=1.096+1.2523881*\mathbf{X_1}-2.34260962*\mathbf{X_2}+0.3259851*\mathbf{X_4}+0.39256214*\mathbf{X_5}+0.97661121*\mathbf{X_{10}}+1.15126269*\mathbf{X_{11}}+0.4202778*\mathbf{X_{12}}-0.02782883*\mathbf{X_{13}}-0.3719106*\mathbf{X_{14}}$$

For Tour with Sub-Tour and Back to Home

$$\mathbf{Y_3= U(hwhwh)}=1.677-2.44380216*\mathbf{X_2}+1.05038514*\mathbf{X_3}+0.02315993*\mathbf{X_7}-0.14177188*\mathbf{X_8}+0.500011*\mathbf{X_9}+0.9795993*\mathbf{X_{10}}+0.5852689*\mathbf{X_{11}}+2.21733199*\mathbf{X_{12}}-0.3301922*\mathbf{X_{14}}-3785812*\mathbf{X_{15}}$$

For Tour with Sub-Tour and Back to Home with Non-Work Activity

$$\mathbf{Y_{4=} U(hwh++h)}=1.208+1.2433451*\mathbf{X_1}-2.84957945*\mathbf{X_2}+0.14212966*\mathbf{X_6}+0.39874664*\mathbf{X_{10}}+0.3487675*\mathbf{X_{11}}+2.50857566*\mathbf{X_{12}}-0.01488643*\mathbf{X_{13}}-0.3727139*\mathbf{X_{14}}$$

For One Primary Tour with at Least One Secondary Tour

$$\mathbf{Y_5= U(hw+wh)}=1.431+1.35706231*\mathbf{X_1}+0.04162396*\mathbf{X_9}+0.03739286*\mathbf{X_{12}}-0.2937172*\mathbf{X_{13}}-0.4164309*\mathbf{X_{14}}$$

Table 8: Aggregated Observed and Modeled Travel Demand

Activity Pattern	Observed Demand	Modelled Demand
hwh	82	81
hw+h	33	33
hwhwh	31	32
hw+wh	24	24
hwh++h	10	10

After the calibration and explanation of the activity-based trip generation model for work commuter, the utility functions or mathematical model of the five typical activity patterns will be obtained. The total number of each activity pattern in each zone can be aggregated by probability method as following.

$N_{ki}=\sum_{kn} P_{kn}\ (i/X_{kn})$

Where, Nki is the total number of the i^{th} pattern in the k^{th} zone and Pkn (i/Xkn) is the choice probability of the i^{th} individual activity pattern of n^{th} individual.

Trip generation can be modeled by multiplying the total number of activity pattern with its corresponding length

$G_{ki} = N_{ki}*$ length

Where G_{ki} is the trip generation motivated by the i^{th} activity pattern in the k^{th} zone, Length is the number of tripe included in the i^{th} activity pattern.

Table shows the observed and modeled aggregate travel demand. The deviation between observed are of minute extent and that means the models are able to predict the aggregate travel demand.

CONCLUSIONS

The following conclusions are drawn from the present study:

- The variable education is found to be insignificant for all type of activity travel patterns
- Those with vehicle ownership are more likely to make the pattern with tour with at least on additional stop for non work activity (hw+h) tour with sub tour returning home (hwhwh) and complex chain with both simple primary tour and at least one secondary tour(hwh++h)
- Students are more likely to make the tour with sub tour retiring to home (hwhwhw) and the public sector employees are more likely t make the pattern with tour with at least on additional stop for non work activity (hw+h)
- Most of the work commuters use the private transport mode for complex activity travel patterns. Complex patterns used in this study are, the tour with at least on additional stop for non work activity (hw+h) the tour with sub tour retiring to home (hwhwh) complex chain with both simple primary tour and at least on secondary tour (hwh++h) and the pattern with work based sub tour (hw+wh)
- In case of travel demand analysis it is observed that the deviation between the observed and modeled travel demand is very small and hence the model is able to predict travel demand for the work commuters correctly.

- Travel demand forecasting model is used to estimate travel behavior and travel demand for a specific future time frame, based on a number of assumptions above.

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